I J C T A, 9(16), 2016, pp. 7691-7696

Modelling of Solar Panel for Efficiency Improvement with Tracking System

S. Souhardha, S. Padmini, M. Mohit Kumar and V. Gopi Kishan

ABSTRACT

The main purpose of this paper is to design a solar panel which is more efficient than the existing ones available in the market by incorporating certain changes during manufacturing process. Changes include materials used, dimensions, connections temperature regulation and the cells used in array which helps in major part of boosting the efficiency. The additional setup is tracking system which is used for tracking the maximum power at a particular point of time. Thus the innovative idea of designing a high efficient and economical solar panel with tracking system has been proposed in this paper which can be utilised as a market product in near future.

1. INTRODUCTION

The earth receives $16*10^{18}$ units of energy which is more than the requirement of living organisms on the earth. It is very important to utilize the maximum energy received from the sun. There are lot of applications based on the solar energy. major role of utilizing the solar power mainly depends on the receiving part which are called as solar collectors.

More energy is prevailed in the visible light region compared with rest of the regions. So the design of collectors which utilizes the visible light for harvesting the energy produces more energy than the other collectors which are dependent on the other regions. A solar cell is one of the collectors which harvest the electrical energy from visible light spectrum

Alexander Edmond Becquerel discovered Photovoltaic effect [13] in 1839. First photovoltaic cell was made by Wilougby Smith in 1873. The studies on photovoltaic cells didn't increase till 1970s. Over the years, new materials and new manufacturing techniques developed to increase the efficiency of solar cells.[1]

2. SOLAR CELL

A solar cell is an electronic device which converts sunlight into electricity. Light reflecting on the solar cell produces both current and voltage necessary to generate electric power. The solar cell is made of silicon. The basic steps in the operation of a solar cell [3] contains both the generation and collection of excited electrons.

The main factors that classifies the solar cells are as follows

Table 1
Parameters effecting PV module efficiency

Effecting parameters	*contents*
External electrical circuits	MPPT'[9](maximum power point tracking), inverters, charge controllers
Internal factors	Temperature, module type, efficiency of solar cells

* *Emails: souhardhachowdary@gmail.com, padminisp81@gmail.com, mohith.kumar6@gmail.com, gopikishan608@gmail.com*

Components mentioned in table 1 are the main factors that affect the efficiency of PV module.

PV cells are produced by using different manufacturing techniques. These techniques decides the purity of silicon content [8] in the cell. The purest variant will be having highest efficiency depending upon the purity of the silicon content, solar cells can be classified as follows.[12]

a. Crystalline-silicon PV cells
   - Monocrystalline silicon cells
   - Polycrystalline silicon cells
   - Ribbon-silicon cells

b. Thin-film PV cells
   - Amorphous silicon
   - cadmium telluride cells
   - copper indium diselenide cells

c. Group 3-5 multi junction solar cells

d. tandem cells

e. organic polymer cells

Solar cells are thin and they will be damaged unless protected. the fabrications also protects the cells from moisture, dust, and corrosion. Mono crystalline solar cells are made up of purist form of silicon(90% - 95%) [4]. A single crystalline or monocrystalline solar cells are more efficient (20% - 24%) than any other cells.

3. PHOTOVOLTAIC MODULE

A PV module consists of a number of interconnected solar cells[15] fabricated into a single unit. The main purpose of encapsulating a set of solar cells is to protect them and their interconnections from the harsh environment.

Photovoltaic module [7] is affected by the change in the efficiency of the solar cell. Depending upon the arrangement and connections of the solar cells, there are different types of panels as follows

a. Aluminium framed and glass layered modules

b. Frameless modules

c. Modules with metal base

d. Double sided modules

Depending upon the purpose and the usage of the solar panels [11] one of the above mentioned type is chosen.

4. SOLAR TRACKER

A Solar tracker increases the efficiency of the solar panel by tracking the sun all day. They are capable to follow the sun and provide to fall sun rays perpendicular to photovoltaic panel surface. In this way, panels use solar radiation efficiently and utilization from solar energy becomes its maximum value. Sun tracking systems are using since early 1980s' and studies on these systems are still proceeding. recently there are two types of solar trackers. they are as follows

a. Active (electrical) tracking system

b. passive (mechanical) tracking system

Active trackers [6] uses sensors in order to detect the direction of sun light whereas the passive trackers are operated manually or by simple motoring setup. active trackers are expensive and consume more power when compared to passive trackers[5, 14].

5. PROBLEM FORMULATION

Maximum power of the solar cells can be calculated as per the Equation (1)

$$P\ \max = Voc\ \times\ Isc\ \times\ FF$$

The efficiency of a solar cell can be obtained as followed as equation (2)

$$\eta = \frac{P\max}{1000}$$

The efficiency of a solar panel can be calculated as per the equation (3) below

$$\eta\% = \frac{P\max}{A\times 1000}\times 100$$

$\eta\%$ = Percentage efficiency

P max = Maximum power in watts

A = Area in square meters.

V_{oc} = Open-circuit voltage

I_{sc} = Short-circuit current

FF = Fill factor

Here the Solar constant is taken as 1000.

6. PROPOSED MODEL

The above Figure 1. shows the sun power maxeon cells which are flexible, durable and smaller than the ordinary solar cells. The arrangement of the terminals is completely different from the rest which reduces

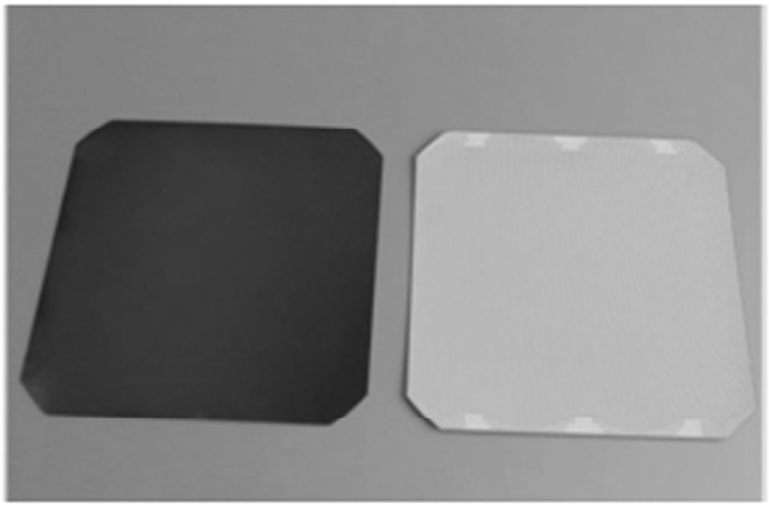


Figure 1: Sun Power Maxeon cells

the chances of short circuiting as well as increases the strength of connections between solar cells of the solar module.

The rated voltage of each cell is 0.5 to 0.6 volts and the rated power which is equal to the product of voltage and current which sums to 2.5 to 3.5 watts.[2]

These cells are very thin and have a capability to work even though there are some damages.

In the above Figure 2 the top most and bottom most layers consist of acrylic glass and wood respectively protecting the inner layers of the module. One of the inner layers consists of 35 pieces of solar cells of the above mentioned which are arranged as 5 in a row and 7 in a column. These are connected in a series pattern that makes terminals from each end. Beneath this layer a poly vinyl chloride (thermal conductivity is 0.19) sheet is used to regulate the internal temperature of solar panel. These all layers are sealed by using silicone sealant which makes it water resistant and dust proof. This whole setup makes an area of 0.598 sq meters.

A solar module cannot produce a constant or a maximum power all the time. In order to reduce this problem and to increase the efficiency a mechanical device called solar tracker is used .Depending upon the size and number of panels ,active or passive solar trackers can be used.

7. RESULT AND DISCUSSION

The above Figure 3. shows the proposed solar panel which consists of 35 solar cells and occupies an area of 0.59 square meters.

Table 2. gives the differences between market panel and the proposed panel. The proposed model differs from the conventional method in the type, arrangement of monocrystalline cells, and fabrication of the solar panel . The thermal conductivity of the proposed model is lesser when compared to the available market models due to incorporation of PVC boards instead of aluminum used. Due to the temperature regulation aspect, the magnitude of current obtained by proposed model is high when compared with conventional solar panel available. Moreover the area of the proposed panel is 0.596 sq meter which helps in efficient concentration of the solar radiations. The increase in efficiency of the proposed model is 6.5% when compared with market panel. Moreover it also reduces the cost by Rs. 2500.

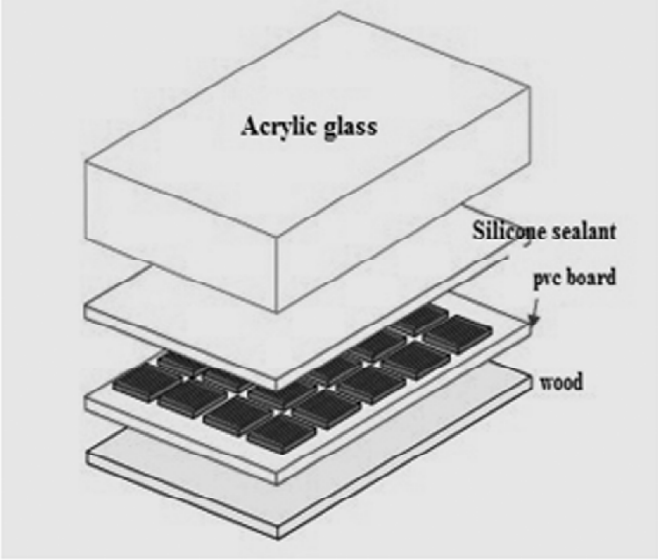
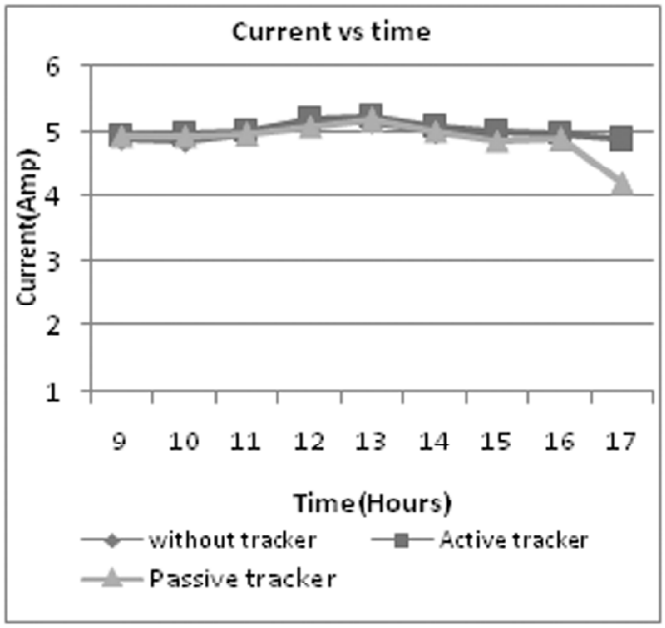


Figure 2: Proposed Model

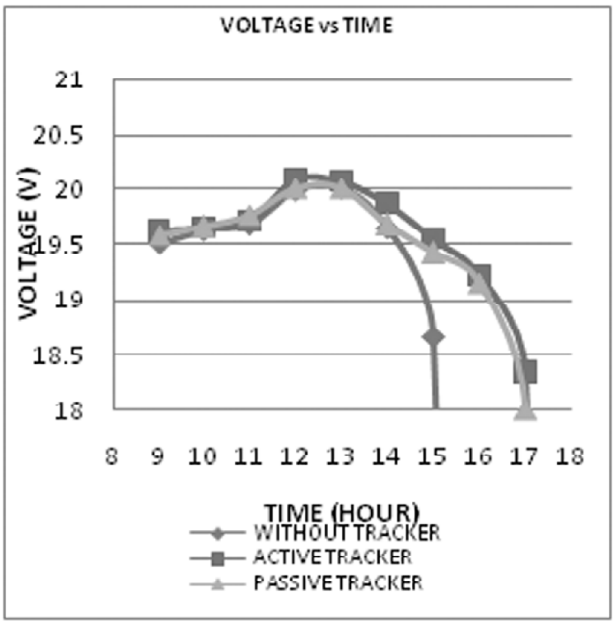
Figure 3: Proposed Solar panel

Table 2
Differences between market panel and proposed panel

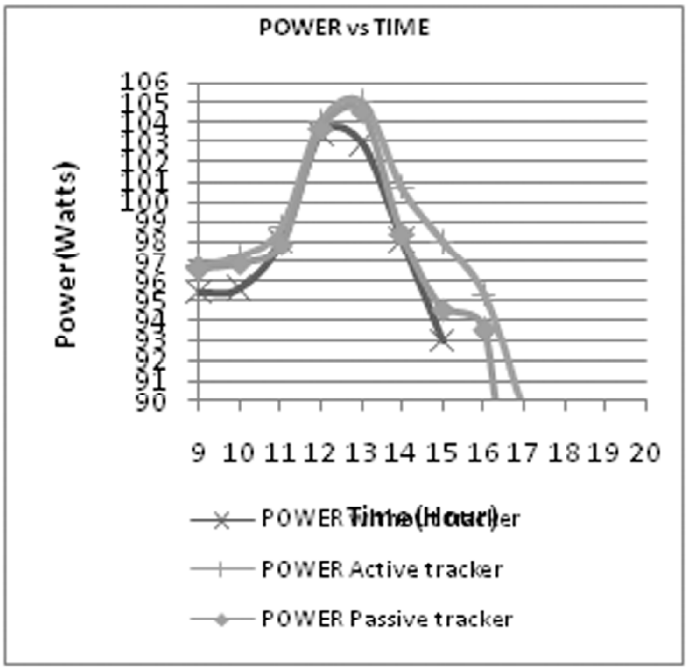
Sl. no	*Output Parameters*	*Market panel*	*Proposed panel*
1	Rated voltage	24 volts	21 volts
2	Rated current	5 amps	5.85 amps
3	Rated power	120 watts	120 watts
4	Total area of the panel	0.821 sq meter	0.596 sq meter
5	Rated efficiency	14.6 percent	20.1 percent
6	cost	Rs. 9000	Rs. 6500



Graph 1: Current vs time graph



Graph 2: voltage vs time graph



Graph 3: power vs time graph

8. CONCLUSION

The generation of electricity using solar technology has seen a tremendous growth. So designing a solar panel with high efficiency and economical along with the tracking system is an innovative idea in this sophisticated technological world. Thus the proposed model can be finely tuned to be made as market product in the future.

REFERENCES

[1] M.A. Green, *Power to People* (Book style). UNSW Press, 2000, p. 24.

[2] http://us.sunpower.com/why-sunpower/high-efficiency-solar-technology/

[3] P. Denholm, and R.M. Margolis "Evaluating the limits of solar photovoltaic's (PV) in traditional electric power systems" *Energy Policy*, vol.35, Issue 5, pp. 2852-2861, May 2007.

[4] "Correlation of operating conditions and solar cell parameters (Thesis style)," Ph.D. dissertation, Dept. Solar Energy, Ege Univ. Bornova, Ýzmir, 2007.

[5] M.J. Clifford, and D. Eastwood "Design of a passive solar tracker" *Solar Energy*, pp.269-280, June 2004.

[6] S. Deepthi, A. Ponni, R. Ranjitha, and R. Dhanabal "Comparison of Efficiencies of Single-Axis Tracking System and Dual-Axis Tracking System with Fixed Mount" *International Journal of Engineering Science and Innovative Technology (IJESIT)*, Volume 2, Issue 2, March 2013

[7] J. A. Gow and C. D. Manning, "Development of a model for photovoltaic arrays suitable for use in simulation studies of solar energy conversion systems", in *Proc. 6th Int. Conf. Power Electron. Variable Speed Drives*, 1996

[8] J. Hyvarinen and J. Karila, "New analysis method for crystalline silicon cells", *in Proc. 3rd World Conf. Photovoltaic Energy Conversion., 2003*, vol. 2, pp. 1521–1524.

[9] T. Chaitanya, C. Saibabu, J.S. Kumari "Modelling and simulation of PV array and its performance enhancement using MPPT (P&O) Technique" *International Journal of Computer Science Networks*, vol.1(1), pp. 9-16, Sep-Oct, 2011.

[10] H. Kawamura, K. Naka, N. Yonekuraa, S. Yamanaka, H. Kawamura, and K. Naito, "Simulation of *I–V* characteristics of a PV module with shaded PV cells", *Solar Energy and Solar Cells*, Feb. 2003.

[11] D. Sera, R. Teodorescu, and P. Rodriguez, "PV panel model based on datasheet values", in *Proc. of IEEE international symposium. Ind. Electron. (ISIE), 2007*, pp. 2392–2396.

[12] W. Xiao, W. Dunford, and A. Capel, "A novel modelling method for photovoltaic cells," in *Power Electronics Specialists Conference, 2004. PESC 04. 2004 IEEE 35th Annual*, vol. 3, 2004, pp. 1950–1956 Vol.3.

[13] A. Lovins, and R. Thomas, *Photovoltaic's and Architecture* (Book style). Taylor and Francis, 2001.

[14] M.J. Clifford, and D. Eastwood "Design of a passive solar tracker" *Solar Energy*, June 2004.

[15] M. Villalva, J. Gazoli, and E. Filho, "Comprehensive approach to modelling and simulation of photovoltaic arrays," Power Electronics, IEEE, pp. 1198-1208, May 2009.

[16] c. Barreiro, P. Jansson, A. Thompson, "PV by-pass diode performance in landscape and portrait modalities," in Photovoltaic Specialists Conference , 2011 IEEE, June 2011.